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(Vol. XVIII.—February, 1888.)

AN AUTOMATIC WASTE WEIR.

By A. D. FOOTE, M. Am. Soc. C. E.

READ JUNE 20TH, 1888.

In constructing canals across the drainage channels of an arid country, the engineer must provide for the sudden and ungovernable floods to which such countries are subject.

Slight though the rainfall may be in these regions, the sun-baked, verdureless hills present an impermeable surface, shedding water, for a time, like a roof, into the dry natural channels which thus suddenly become dangerous torrents. The most insignificant of these channels may, at intervals perhaps of years, become a river.

Canals crossing the drainage of such a country, must be carried either over or under all natural channels; or ways must be provided for the passage of such channels through the canals. The first two methods, if properly carried out, are excellent, but their enormous cost in most cases renders them impracticable. The third method is also often too expensive to be employed, especially where small channels are numerous. It is therefore only too common that canals are constructed without any provision for flood waters and in consequence are often washed out.

Mr. C. H. Tompkins, Jr., and myself have for some time been working over the problem of passing sudden flood waters through a canal at no great cost and without interfering greatly with its capacity.

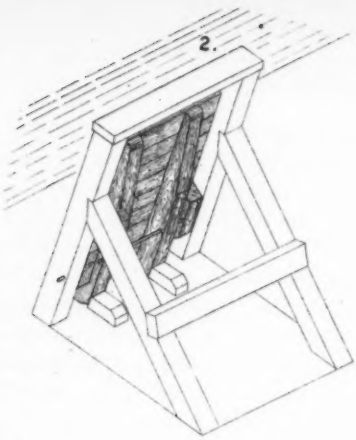
The accompanying drawing shows a form of gate which we have found perfectly to fulfill the above requirements so far as experiment shows. (Plate II.)

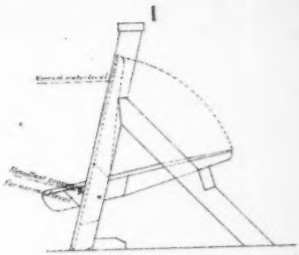
We have a working model set in an earth dam, in a small creek. It takes about ten minutes for the water to rise upon the closed gate to a height sufficient to open it. About two minutes are then required to lower the water to the point at which the gate closes again automatically. It is now over a month since the gate was put in operation, and in spite of poor workmanship in the model and the natural swelling and warping of wood, which, in so small a model, causes much more friction in proportion than in a large gate, the little affair has never failed to open at the proper time and has never failed to close again, except when some drift was caught in it. Had it ever failed to open, the water would have raised over the small earthen dam, and washed it away, as no other waste weir is provided.

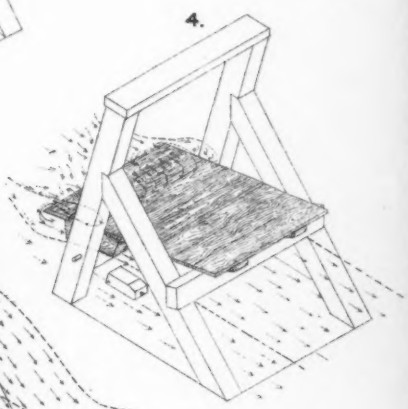
The drawing needs but little explanation. The gate is hung upon horizontal pivots, so placed that the water held in by the gate cannot rise above a certain point without raising the center of pressure above the pivot. When the center of pressure is raised high enough to overcome the friction and inertia of the gate, it opens; the top moving backward or down stream, until caught by a cross-piece, so placed that when the escaping water has been lowered to a certain point, the pressure, being removed from the upper portion of the gate, acts upon the lower portion only, and closes the gate.

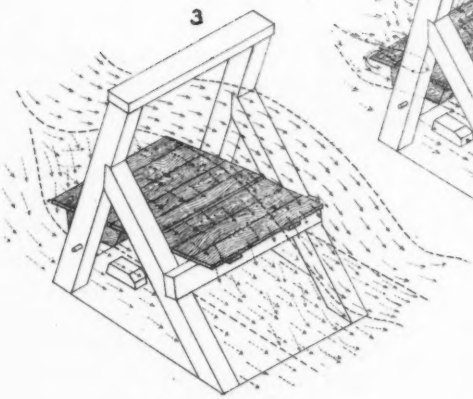
In building these gates the pivot should be placed at the two-thirds point, measuring perpendicularly from the normal level of the full canal. The gate should be set at an angle from the perpendicular outward that will enable it to stand firmly without water against it. The distance from the normal level of the full canal surface to the top of the gate should be as great as the banks of the canal will allow. It will readily be seen that the greater this distance the greater will be the pressure of water for the purpose of overturning the gate, in case of any undue friction that may occur. The gate, when closed, should stand flush with the line of the side of the canal, so that there will be no opportunity for sediment to gather in front of the bottom of the gate.

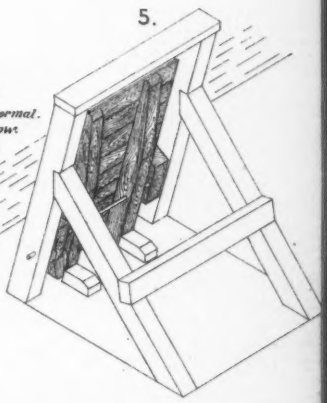
In the drawing, the width of the gate is 6 feet, the depth of water at the normal level is 7 feet, and the height of the gate is 8 feet; con-











1. *End Elevation.*
2. *Gate closed, water level at normal height.*
3. *Gate opened by water level rising above normal. — Water escapes both above and below.*
4. *Gate on point of being closed by pressure of water acting on lower portion.*
5. *Gate closed, with water level reduced.*

Scale for Elevation

Isometric scale

AUTOMATIC WASTE WEIR

DESIGNED MARCH–1888 } BY { A.D. FOOTE, C.H. TOMPKINS Jr.

March 30th 1888.

sequently when the water rises one foot above the normal level, it is exerting a pressure of 187 pounds upon the upper portion of the gate toward opening or overturning it. It will be a grievous fault in the construction of the gate if it fails to open under these conditions.

The angle at which the gate shall stop against the cross-piece, as shown in Figs. 3 and 4, is about 8 degrees from the horizontal. The amount of pressure exerted by the water upon the lower end of the gate to bring it back to its upright position, is not so easily calculated as the pressure that opens it. When the water is down, nearly to the level of the pivot of the gate, the rush of the current piles it up on the lower end of the gate so that the pressure exerted to close it is much greater than if the water were quiet. The amount of pressure will depend upon the angle at which the gate is held by the cross-piece.

Brush, or other *débris*, may clog the gate and prevent its shutting automatically, but this will entail no loss, except the waste of water while the gate is allowed to remain open. Where it is advisable to have the upper side of the canal kept uniform, ordinary barn-door gates, opening into the canal, can be used to allow the flood water to pass into and through the canal.

This weir can also be used to great advantage as an additional security for reservoirs. By placing them on a portion of the waste weir, they can be so arranged that a foot rise in the reservoir will quadruple, or more, if advisable, the capacity of the waste weir, by instantly adding several feet in depth to the overflow. They would save the expense and danger of an enormously long weir, and would give the desired capacity without lowering the ordinary height of the weir. By putting in a sufficient number, they would make it impossible for the water ever to rise to a dangerous height in the reservoir.

It also seems to me that they might be adapted for use in the automatic flushing of sewers, but in this kind of work I have very little experience. The gates could be so arranged as to require but a small amount of water to open them, and they undoubtedly will turn the water loose all at once. By properly arranging the flow above the gate they could be made to dump the water at desired intervals.

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NOTES ON THE CLASSIFICATION OF RAILROAD ACCOUNTS AND THE ANALYSIS OF RAILROAD RATES.

BY GRATZ MORDECAI, ASSOC. AM. SOC. C. E.

READ FEBRUARY 15TH, 1888.

Something over a year ago I was requested by the United States Commissioner of Labor, Mr. Carroll D. Wright, to trace out what may be termed the development of the cost to the final consumer of some of the principal articles of domestic production and consumption—examining and analyzing each separate step, and then combining them all in a condensed summary; and though the investigation called mostly for statistical work, it may be that some of its phases will prove of interest.

Especially may this be the case in that part relating to the cost of transportation; and while I do not intend to give the final results in any case, it will do no harm to present my general methods with some special examples.

To be sure such an investigation must always be carried on from the one point of view of the final consumer and not from the many points of view of the individual operators; it must be definite and limited in its scope; it must start the initial raw material from a certain district or place at a definite date, and carry it by regular and representative methods through its whole course. For instance, iron ores mined in Michigan, carried in June by lake and rail to the furnaces and mills of the Mahoning Valley, and there other supplies added and work done and finally delivered as nails to a carpenter in Dayton, Ohio; or wool grown on a farm in Ohio, made into cloth in New England, into clothing in Chicago, and sold by a retail dealer at Minneapolis; and in like manner each step which goes to make the cost of bread sold by a baker in Second avenue, New York City, and of beef sold by an East side butcher. It is evident that in order to make such investigations at all accurate in detail, or at all instructive in results, it is not only necessary to adopt a definite time and market price, representative points and a quick movement (storage and speculation are not considered), but that a certain general scheme of analysis should run through the whole, applicable alike to the work of a small farmer or a great railroad, of a wealthy merchant or a peddler. In fixing this general scheme of analysis I was greatly assisted by studying the working of a blast furnace, which is a concentrated operation, and yet contains the elements of any business and allows of a compact and simple method of keeping accounts. The value of the method I adopted comes from the almost mechanical consistency of its application.

It can be very safely assumed that all work contains three main elements of cost to the consumer:

1st. The cost of operating; 2d, the cost of soliciting; 3d, the cost of managing (which includes the profit of the operator) and under these heads it is not difficult to discern certain well-defined divisions. 1st, The cost of capital, such as rent and taxes; 2d, the cost of labor of all kinds; 3d, the cost of supplies consumed; 4th, the cost of repairs (in which labor and material should be always separated). The sum of these represents the total gross cost to the consumer, and by subtracting from this total (5th), the incidental receipts of the operator from waste and other sources, the market price or actual cost to the consumer is obtained. In some operations, as for instance, a dealer on an exchange, the work of operating is absent; but as a general thing, all these elements are present and also the five subdivisions under each head as is shown by the tables and examples.

Its application to railroad work is expressed in the general tabular form, Table No. 1 and special examples, Tables Nos. 2, 3 and 4. This general form applies both to the total yearly work (Table No. 2) and to special freight movement (Tables No. 3 and 4), but it is best to explain a few points before using it in the latter way.

The cost of capital, under the head of operating, in all the work of production and sale, is taken as the interest on the total cost or present value (in other words the rental, actual or deduced) of the work. In railroad work, however, it is only taken as the sum of all the fixed charges and no effort is made to fix the total cost or value of a railroad and equipment.

Hence in the first case the profit or loss under the head of managing work represents only the return for the work done, whilst in railroad work it represents only the return for the capital invested by the stockholders, and it is not considered that there is any return for the work done, and this appears for several reasons (being purely a transmitting work) to be a logical distinction, and in some cases doubtless a true expression.

To be sure, the work of managing depends upon the individual opinions and aims of the managers, their general and special policy, as well as the effects of supply and demand and of competition, and hence in analyzing any special market price at a given time, no attempt is made to separate the items of cost of this work of managing, nor any effort made to state the exact profit or loss on any particular movement. Still the difference between the market price and the sum of the cost of the commercial work of operating and soliciting always represents the cost of managing as a whole. Where the market price is greater than the total cost of the commercial work, the difference represents the net cost to the final consumer of the work of managing. Where the balance is the other way and the market price is less than the cost of the commercial work, the difference or loss of the managers represents the net receipts which the final consumer gets from the work of managing. Therefore, to obtain this lump cost of, or receipts from the work of managing in any given case, it is necessary to determine the cost of operating and soliciting, and the methods I have adopted in doing this in railroad work may be of interest. They have all been derived as correctly as possible from the published reports to stockholders and State officers. It may be well to state clearly that it is, and always will

be, impossible to obtain the exact cost even of the simple operating and soliciting work of moving any particular article at a given time between two given points by railroad, but I will proceed to give some special results, and in a general way state how they are obtained.

First.—The fixed charges actually paid chargeable to road freight work are all added up and divided by the total yearly ton mileage of the system, and this result multiplied by the number of miles the special article is moved over the system, gives the cost of capital chargeable to that movement. Car service and interest charges are charged against road work, but if there are any rentals or charges exclusively against terminal work, they are divided per ton handled, and added.

Then the cost of road labor, superintendence, train hands, watchmen, proportion of the agents, etc., is divided by the total ton mileage, and the result multiplied by the number of miles moved, and to the product is added the cost of terminal labor on the special article examined, derived largely from the excellent tables given by Mr. Octave Chanute, M. Am. Soc. C. E. The sum gives the total cost of labor chargeable to the special movement. Then the cost of fuel and supplies consumed, and of road and rolling stock and terminal repairs are treated in a similar way, and from the total sum is subtracted the total incidental receipts, also obtained by a similar method, resulting in the approximate net cost of operating that special movement. A similar method is adopted with the cost of soliciting work, and the total of operating and soliciting work subtracted from the special freight rate gives the total net result of the work of managing, chargeable to that special movement.

As many of these latter expenses of managing are of special application and indivisible per unit, no attempt is made to separate or define the items, and it is simply taken in all cases and in all work as the lump sum representing the cost of or receipts from the work of managing. It is a constant and interesting item in examining the cost of the work of a farmer or a manufacturer, of a retail dealer, or a railroad company. One of the specific examples here taken shows that the movement of a barrel of flour from Minneapolis to New York is done at less than the actual cost of the commercial work, and that the consumer receives thirteen cents from the managers of the railroad as their loss on the movement. But it must be noticed that this is less than the cost of the fixed charges chargeable to this work (twenty-eight cents), hence the difference (fifteen cents) is the amount earned from this movement towards paying the

fixed charges, and, therefore, this rate, fixed by supply and demand by competition and by public and corporate policy, is justified, especially when we consider the large yearly movement, and the resulting burden which would be thrown on other traffic if this movement were abandoned by the trunk line railroads, and the great public advantages arising therefrom ignored. Local business and more expensive goods which can bear higher rates, and are moved in smaller total quantities, do not separately pay as large an amount of fixed charges, but pay more of the cost of managing, including profit, which is large by unit of weight, though it may be small in total amount. It is thus seen that a large and long movement which actually does not pay the "cost of operating" may be more valuable to a railroad in helping it to earn its fixed charges than a considerable though short movement, yielding a large relative profit to the management.

This system of accounts is carried on uniformly through all the operations of commerce, resulting in the detailed analysis and development of the final cost to the consumer, and condensed summaries thereof.

In railroad work the basis of the system is the average cost of road work per ton mile, certain allowances being made for freight costing more or less than the average in some cases, and special additions being made for terminal and soliciting work, and the remainder representing the work of managing.

This plan is similar to the formulas prepared by Mr. Albert Fink, Past President Am. Soc. C. E., but I have tried to classify the items in order to separate clearly dissimilar and incongruous elements often found mixed in railroad reports. I have introduced the three main heads of operating, soliciting and managing, and have attempted to follow out under each the five sub-heads of capital, labor, supplies, repairs and incidental receipts, which last I have tried to express in each case in figures, for I have found that it is an important consideration in the clear understanding of commercial work.

TABLE No. 1.

General Analysis of the Cost to the final Consumers of the Movement of Freight on Railroads.

Chief elements of cost to the final consumers.	Cost of Railroad's Work of				Final cost of freight movement or railroad's gross freight receipts.	Per cent. of Final cost.
	Operating.		Soliciting.	Managing.		
	Road work.	Terminal work.				
In analysis of any definite rate.	Divide by ton mileage.	Special.	Divide by ton mileage or special.	Not Specified.		
Cost of Capital, paid to owners of money, property, franchises and rights.	(Proportion.) Interest paid on bonds. Rentals. Car Service. Fixed Charges.	Rentals. Car Service. Fixed Charges.	Rents of Offices, etc.	Taxes, etc. Stockholders' receipts, dividends, surplus, etc., credited to freight movement. (Proportion.)	Total cost of capital chargeable to freight.	Deduced.
Cost of Labor, paid to workmen.	Train superintendence, Watchmen, Clerks, etc.	Yard-house superintendence, etc.	Freight and soliciting agents, and Clerks, etc.	General Officers. General Clerks. Legal, etc. (Proportion.)	Total cost of labor Chargeable to freight.	Deduced.
Cost of Supplies, paid to producers and merchants.	Fuel, oil, water, waste, etc.	Fuel, oil, water, waste, etc.	Fuel, Office supplies.	Investments. Banking. Money in use, etc. (Proportion.)	Total cost of supplies chargeable to freight.	Deduced.
Cost of Repairs to, paid to workmen and merchants.	Plant. (Labor and material separate.)	Plant.	Offices, etc.	Insurance, Losses, Discounts, etc. (Proportion.)	Total cost of Repairs chargeable to freight.	Deduced.
Gross Cost.	Total.	Total.	Total.	Total.	Total Gross.	Deduc'd
Less incidental receipts of railroads, etc.	Rents Supplies Waste Use of road.	received. sold. sold. Use of Termini.	From rents, waste, etc.	From stockholders' interest on investments, etc; also from stockholders' losses; final loss	Deduct incidental receipts chargeable to freight.	Deduced.
Net cost to final consumer.	Net Cost.		Net Cost.	Net Cost.	Final cost or railroad's fr't earnings, *i. e.*, gross receipts from freight.	100.0
Per cent. of final.	Deduced.		Deduced.	Deduced.	100.0	

Note.—All transfer work in road-work. Termini are where a station yard engine is used.

TABLE No. 2.

Analysis of the cost to the final consumers—being Railroad's gross Freight Earnings—due to the movement of freight in the year 1886 on the main line and branches of a Trunk-line Railroad having a terminus at New York City (figures deduced from annual report).

Total miles of road operated.. 1 441 miles.
" freight moved..... 12 718 101 tons.
" freight mileage.....2 414 266 463 ton miles.

Elements of Cost.	Cost of Railroad's Work of				Total Cost.	Per Cent. of Final Cost.
	Operating.		Soliciting.	Managing.		
	Road.	Termini.				
Cost of Capital.....	5 082 840	54 240	100 000	*3 408 128	8 645 208	47 $\left(-9^{A}=38 \text{ Nett.}\right)$
" Labor	2 792 547	2 842 732	364 972	236 140	6 236 391	34
" Supplies.....	1 220 156	109 256	5 000	19 447	1 353 859	7.5
" Repairs.....	3 510 267	200 000	.....	156 897	3 867 074	20.5 { About ½ labor. " ½ mat'l.
Total Cost gross.....	12 605 810	3 206 228	469 972	3 820 522	20 102 532	109.0
Less incidental receipts..	1 000 000		.....	626 000	1 626 000	A 9.0 { Part of dividends hence are taken from capital cost — above A.
Net Cost.....	14 812 038		469 972	3 194 522	18 476 532	100.0
Per Cent. of Final Cost...	80.0		2.5	17.5	100.0	

NOTE.—All general items not specially allotted in the report to either passenger or freight business (such as interest, rents, dividends, etc., all paid and received) are here allotted to freight movement in the proportion that the earnings from freight movement bear to the total (operating) earnings.

*The actual dividends and surplus for the year chargeable to profit on freight movement amounted to $866 135. The remainder of this charge comes from taxes ($916 877) and incidental receipts—rents, etc., $1 626 000 allottable to freight movement, and this last item forms the chief part of the yearly dividends and surplus which really arise more from incidental receipts, rents, mail, express, etc., than from profits on passenger and freight movement.

TABLE No. 3.

Analysis of the cost—to the final consumers—of moving a barrel of flour (215 pounds gross) by rail from a mill in Minneapolis to a freight pier in New York City over three independent railroads having a through freight rate over the route, which is 1 400 miles long : 420 miles over the first, 540 miles over the second and 440 miles over the third or Eastern.

Cost of Railroads' Operating (variable) per Barrel, October, 1887.

Cost of Capital, interest, fixed charges, rents, etc.....	0.28	
" Labor, on roads and at terminal points.....	0.18	
" Supplies—fuel, etc	0.09	
" Repairs, to plant, labor and material.....	0.25	
Total cost of operating.....	0.80	
Less incidental receipts.....	0.03	
Net cost of operating.....		0.77

Cost of Railroads' Soliciting (variable) per Barrel.

Cost of capital, 0.00; labor, 0.01; supplies, 0.001; repairs, 0.001.	0 01
	0.78

Receipts from Railroads' Managing (Items indivisible).

Cost of Capital, taxes, etc.....		
" Labor, general officers, legal, etc		
" Supplies, banking, investments, etc.....		
" Repairs, insurance, losses, etc.....		—0.13
Total cost of managing.		
Less receipts from incidental sources.		
Net receipts from managing, including, but not stating, railroads' net loss on this movement	—0.13...	
Final cost to the consumer or through freight rate per barrel of flour—Minneapolis to New York—October, 1887.... (This is a large total movement.)		0.65

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TABLE No. 4.

Analysis of the cost to the final consumer of moving a case of dry goods (220 pounds gross) between two local stations 60 miles apart on one of the railroads referred to on Table No. 3.

Cost of Railroad's Operating (variable) per Case.

Cost of Capital, interest, fixed charges, etc	0.01	
" Labor—on road and at stations	0.02	
" Supplies, fuel, etc	0.01	
" Repairs to plant (labor and material)	0.02	
Total cost of operating	0.06	
Less incidental receipts	0.00+	
Net cost of operating		0.06—

Cost of Railroad's Soliciting (variable).

Cost of Capital. Labor, 00+ Supplies. Repairs. 0.00+

Cost of Railroad's Managing (Items indivisible).

Cost of Capital, taxes, etc		
" labor, general officers, legal, etc		
" supplies, banking, etc		
" repairs, insurance, losses, etc		
Total cost of managing		0.27
Less receipts from investments, incidental, etc		
Net cost of managing, including, but not stating, railroads' profit on movement	0.27	
Final cost to consumer or local freight rate for 60 miles, a general rate between several local stations, 15 cents per 100 pound (small total movement)		0.33